geous for controlling and maintaining a uniform heating and cooling profile throughout the microchannel device during the filling and draining process. As an example, it would be particularly advantageous to raise the device temperature from the first to the second temperature by flowing a heat exchange fluid from one direction in the adjacent heat exchange microchannel. The transient nature of this process will reveal that the first end of the microchannel that sees the higher temperature heat exchange fluid first and will raise in temperature first. The transient time for moving the average microchannel temperature from the first to the second temperature may be less than 30 minutes, preferably less than 10 minutes, and more preferably less than 1 minute. If the time to raise the temperature of the device is within 10% of the total time required for the surface reaction or adhesion process to retain the fluid on the microchannel wall, then the cool down could be performed in reverse, whereby the heat exchange fluid enters from the second end of the microchannel such that the total time at temperature for both ends of the microchannel is roughly equivalent and thus minimizing interchannel non-uniformity during draining.

[0338] Performance calculations were completed for the methane steam reforming design showing the impact of non-uniform coating on the combustion or heat generation microchannel. When the catalyst was more than 20% reduced near either the top or bottom of the channel (as defined by the top 20% or bottom 20% of the channel), then the emissions performance metric (400 ppm or 99.3% methane combustion) could not be achieved. If the performance metric for the reactor were less stringent, then a higher degree of non-uniformity would be allowed.

[0339] A relationship between the required approach to theoretical performance and allowable catalyst non-uniformity is challenging to fully assess and has not yet been fully quantified for all reaction cases. Performance metrics include absolute conversion (as in the case of emissions), selectivity (as in the case for partial oxidation reactions), approach to equilibrium conversion (as in the case of methane reforming at pressure or other equilibrium-limited reactions), maximum metal or catalyst temperature (as in the case to prevent a deleterious hot or cold spot in the reactor), thermal strain (as in the case of too active catalyst near a high strain region that might create thermal gradients sufficient to reduce the mechanical integrity or lifetime of a device), among others. It is envisioned that a catalyst uniformity to within 20% should be acceptable for most cases, and a higher degree of catalyst non-uniformity may be allowed in some cases.

[0340] Heat Treatments

[0341] Inconel™ 617 coupons were aluminidized and heat treated under a variety of conditions. A coupon aluminidized to form the aluminide coating, but not oxidized, is shown in **FIG. 16**. The aluminide layer was about 30 μm thick and there was an interdiffusion zone between the aluminide layer and the alloy that was about 5 μm thick. The aluminide layer contained 28 to 31 wt % Al which corresponds to NiAl.

[0342] Heat treament of an aluminidized coupon at 1100° C. for 100 hours caused the interdiffusion zone to essentially disappear and there was a substanital loss of aluminum from the aluminide layer into the alloy. Treatment of an aluminidized coupon at 1050° C. for 100 hours did not show significant loss of the aluminide coating.

[0343] Effect of Oxide Presence During Aluminidization Process

[0344] **FIG. 17** shows a comparison between a standard aluminidized coupon and a coupon heat treated in air at 400° C. for 1 hr to purposely grow some native oxide of chromia before being aluminidized. A thin dotted line of inclusions in the aluminide is observed in the coupon with native oxide before aluminidization. Such a line of inclusions could become a weak point in terms of adhesion. Reference to these figures should be taken when deciding whether an aluminide layer is substantially with or without oxide defects between an aluminide layer and a metal substrate.

[0345] Coating defects were also observed on FeCrAlY fins that were aluminidized in the presence of an alumina disk. **FIG. 18** shows large voids in the aluminide layer of an Inconel™ 617 coupon that was aluminidized in the presence of an alumina disk.

[0346] In early attempts at the aluminidization of a multichannel device, it was discovered that the channels nearest the gas inlet (that is, the inlet for the aluminum compounds) showed the most inclusions while the channels furthest away showed the least. This is believed to have been caused by surface oxides in the tubing or manifolding in the pathway of the aluminum compounds prior to the microchannels. The presence of surface oxide in the tubing was confirmed by EDS. To avoid these defects, care should be taken to avoid the use of components that have surface oxides in the aluminidization process, especially surface oxides along the fluid pathway (that is, the pathway carrying aluminum compounds) leading to a microchannel device. In some preferred techniques, the tubing and/or other fluid pathways are subjected to a treatment to remove surface oxides (brightened), such as by a hydrogen treatment. Of course, before aluminidization, the microchannels may also be subjected to a treatment for the removal of surface oxide.

[0347] In preferred embodiments, the aluminide layer and the interfaces of the aluminide layer with the alloy substrate and an oxide layer (if present) is preferably substantially without voids or inclusions that are larger than 10 μm, more preferably substantially without voids or inclusions that are larger than 3 μm. "Substantially without voids or inclusions" excludes coatings such as shown in **FIG. 14** and other structures having numerous (that is, more than about 5 large or a single very large) defects in 50 μm of length along a channel, but wouldn't exclude a structure shown on the left of **FIG. 13** that shows a small number of isolated defects.

EXAMPLE

[0348] Comparative uptake and reaction performance tests were conducted with a flat microchannel compared to a microchannel with capillary features recessed within the wall. The capillary features are also referred to as microfins in this example. The tests were conducted for a combustion reaction. The capillary features were un-optimized in this example and unpreferably vertically oriented with the direction of gravity and process flow.

[0349] Testing was conducted with combustion catalyst formulations in both test devices. The first test device was a 2" long 0.5" diameter Inconel 617 rod with a 0.375" by 0.045" axial slot flat microchannel cut within it using wire EDM. The second test device was a 2" long 0.5" diameter